

## CLAIMS

1. A method for controlling the final thickness of a rolled product at the outlet of a rolling mill including at least two roll stands operating in tandem and each determining a portion of the global reduction in thickness to be carried out, by running the product between two working rolls, each stand being associated with means for applying an adjustable clamping load between the working rolls and driving means for applying, to the working rolls, a rotational driving torque at an adjustable speed, the plant being associated with a general speed control system of the different stands determining gradual increase in the rotational speed of the rolls in relation to the gradual variation in thickness from one stand to the next, and to a device for controlling the reduction in thickness and in tension of the product in each space between two successive stands, characterised in that the control device performs, in real time, dynamic balance, between the different stands, of the torques applied, in each stand, on the working rolls without any noticeable disturbance of the final thickness  $h_5$  of the product at the outlet of the plant.

2. A method according to claim 1, characterised in that the control device controls a variation in the rolling speed in at least one of the stands and modifies consequently the distribution of the reduction in thickness and the gradation of the speeds between the different stands in order to distribute substantially equally over the driving means assembly the load to be applied for driving the product at a given speed at the outlet of the plant while maintaining the final thickness  $h_5$  at a set speed.

3. A method according to one of the claims 1 and 2, wherein the global reduction in thickness to be performed between the inlet and the outlet of the plant is distributed, according to a rolling pattern, using a pre-adjustment system determining the reduction in thickness to be performed by each stand and correlative gradation of the rotational speeds of the working rolls, characterised in that permanently the load imposed, in each stand, to the rotational driving means of the working rolls for obtaining the speed set by the rolling pattern is detected and the reduction in thickness allocated to the most loaded stand is decreased in order to provide dynamic balance of the loads applied on the different stands.

4. A method according to claim 3, characterised in that, to decrease the reduction in thickness allocated to the most loaded stand, the rotational speed of the rolls of said stand is diminished with respect to the speed set by the rolling pattern.

5. A method according to claim 4, wherein the speed reduction of the most loaded stand determines automatic reduction in speed of the product at the inlet of the following stand which generates a potential thickness defect at the outlet of the plant during a transient period of product infeed in the inter-stand space, characterised in that this potential thickness defect is compensated for by anticipation by controlling reverse variation of the speed of all the stands situated upstream of said most loaded stand, liable to decrease the reduction in thickness performed in said upstream stands, in order to perform a load transfer on the stands placed downstream of said most loaded stand.

6. A method according to claim 3, characterised in that to decrease the reduction in thickness to be performed by the most loaded stand, the rolling speed is increased in the previous stand situated immediately upstream, in order to decrease the thickness of the product before arriving in the most loaded stand.

7. A method according to claim 6, wherein the increase in speed in the previous stand determines automatic increase in the speed of the product at the inlet in the most loaded stand which generates a potential thickness defect at the outlet of the plant during a transient period of product infeed of the previous stand at the most loaded stand, characterised in that this potential thickness defect is compensated for by anticipation while controlling an increase in the rolling speed in at least one stand situated still upstream of said previous stand, in order to perform a load transfer on all the stands placed upstream of the most loaded stand, while increasing the reduction in thickness performed in each thereof.

8. A method according to claim 5, characterised in that the variation in thickness of the product is monitored permanently as it progresses from the first to the last stand of the plant, in order to control a variation in speed of certain stands liable to compensate for a potential thickness defect for a transient period corresponding to the time necessary beforehand between two successive stands, respectively upstream and downstream, of the

variation in thickness resulting from a variation in speed of the upstream stand, in order to hold constant, permanently, the thickness  $h_5$  of the product at the outlet of the last stand of the plant.

9. A method according to claim 8, characterised in that after detection of the most loaded stand, the variations in speed are combined on both sets of stands situated respectively upstream and downstream of the most loaded stand while producing a load transfer towards certain stands of said upstream and downstream sets according to the load detected, in order to balance the loads on all the stands of the plant, while holding constant the final thickness  $h_5$  of the product at the outlet thereof.

10. A method according to claim 1, characterised in that, after performing dynamic balance of the loads applied on all the stands, the rolling speed in one of the stands is increased and the control system causes consequently the speeds of the other stands to vary in order to increase the speed of the product (B) at the outlet of the plant without disturbing the final thickness and while preserving dynamic balance between all the stands.

11. A method according to claim 10, characterised in that the increase in the overall speed of the plant represents a gain of up to 15 % of the maximum speed obtained without the dynamic balance of the torques applied.

12. A method according to claim 1, wherein the driving means of the rolls are electric motors, characterised in that the control system performs dynamic balance of the currents, without exceeding a rated intensity in each motor.

13. A device for controlling the final thickness  $h_5$  of a rolled product in a tandem rolling mill including at least two roll stands spaced apart from one another, and determining each a portion of the reduction in thickness, each stand including at least two working rolls delineating a gap for letting through the product, means for applying an adjustable clamping load between said working rolls and motorised means for driving said rolls into rotation at an adjustable speed, the plant being associated with a general speed control system of the different stands determining gradual increase in the rotational speed of the rolls in relation to the gradual variation in thickness of a stand (i) at the next (i+1), and to a device for controlling the reduction in thickness and

in tension of the product in each space between two successive stands, wherein

the control device includes a closed-loop circuit for dynamic balancing, between the different stands, of the torques applied by the motorised means of each stand in order to obtain the final thickness desired  $h_5$  and to maintain the latter at substantially constant value.

14. A device according to claim 13, for controlling the final thickness  $h_5$  of the rolled product at the outlet of a rolling mill wherein the overall speed control system is associated with a pre-adjustment system of the reduction in thickness allocated to each stand, determining, for each stand, a speed setpoint to be applied to the motorised means for gradual increase in speed corresponding to the variation in thickness from one stand to the next, characterised in that the dynamic balancing circuit includes means for correcting, on each stand, the speed setpoint determined by the pre-adjustment system in order to modify the distribution of the reduction in thickness between the different stands.

15. A control device according to claim 14, characterised in that the dynamic balancing circuit includes a module for controlling the transients acting as a closed-loop on the driving means of the rolls, in order to provide by anticipation, an additional correction to the speed setpoint for a transient infeed period of the product between a stand (i) whereof the speed setpoint has been corrected and the following stand (i+1).

16. A control device according to claim 15, characterised in that the module for controlling the transients is associated with means for permanent tracking of the variation in thickness of the product when running between the inlet and the outlet of the plant, which determine the instants of the beginning and of the end of the transient period during which an additional correction is made to the speed setpoint of at least one of the stands (i).

17. A control device according to claim 16 characterised in that the dynamic balancing circuit of the currents of the motors and the module for controlling the transients have been designed with a final outlet stage for controlling the variations in the speeds including a proportional, integral and differential controller.

18. A rolling mill including at least two stands operating in tandem, fitted with means for adjustable clamping of the rolls and with electric means

for driving said rolls into rotation and including means for controlling the thickness of outlet of the product and the tractions between the stands, a pre-adjustment system of the rate of reduction in thickness of each stand and a general speed control system of all the roll stands, characterised in that it includes a device for balancing the currents of the driving motors of the stands operating as a closed-loop.

19. A rolling mill according to claim 18, characterised in that the device for balancing the currents of the driving motors includes means for correcting the speed setpoint of at least one of said motors, established by the pre-adjustment system.

20. A method according to claim 7, characterised in that the variation in thickness of the product is monitored permanently as it progresses from the first to the last stand of the plant, in order to control a variation in speed of certain stands liable to compensate for a potential thickness defect for a transient period corresponding to the time necessary beforehand between two successive stands, respectively upstream and downstream, of the variation in thickness resulting from a variation in speed of the upstream stand, in order to hold constant, permanently, the thickness  $h_5$  of the product at the outlet of the last stand of the plant.

21. A method according to claim 20, characterised in that after detection of the most loaded stand, the variations in speed are combined on both sets of stands situated respectively upstream and downstream of the most loaded stand while producing a load transfer towards certain stands of said upstream and downstream sets according to the load detected, in order to balance the loads on all the stands of the plant, while holding constant the final thickness  $h_5$  of the product at the outlet thereof.